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NATIONAL DAM SAFETY PROGRAM. MACH LAKE DAM (MO 30133), MISSISSI--ETC(U)
APR 81 S L BRADY, G WERTEPNY, D DANIELS DACW43-81-C-0005

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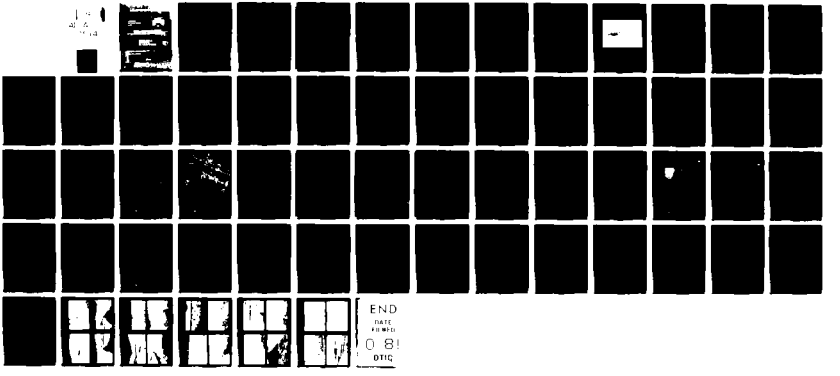

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Mach Lake Dam (MO 30133).
Mississippi - Kaskaskia - St. Louis River Basin, Perry County, Missouri. Phase I Inspection Report.

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10 Steven L. /Brady Gene /Wertepny
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO ATTENTION OF

SUBJECT: Mach Lake Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Mach Lake Dam (Mo. #30133).

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

a. Spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.

b. Overtopping of the dam could result in failure of the dam.

c. Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY: SIGNED — Chief, Engineering Division — 23 JUL 1981 — Date

APPROVED BY: SIGNED — Colonel, CE, Commanding — 24 JUL 1981 — Date

MISSISSIPPI - KASKASKIA - ST LOUIS RIVER BASIN

MACH LAKE DAM
PERRY COUNTY, MISSOURI
MISSOURI INVENTORY NO. 30133

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Prepared By

Anderson Engineering, Inc., Springfield, Missouri
Hanson Engineers, Inc., Springfield, Illinois

Under Direction Of

St. Louis District, Corps of Engineers

For

Governor of Missouri

April, 1981

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM
SUMMARY

Name of Dam: Mach Lake Dam
State Located: Missouri
County Located: Perry
Stream: Tributary to vacant Hollow Goose Creek
Date of Inspection: January 28, 1981

Mach Lake Dam was inspected by an interdisciplinary team of engineers from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The purpose of this inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers, and they have been developed with the help of several Federal and State agencies, professional engineering organization, and private engineers. Based on these guidelines, the St. Louis District, Corps of Engineers has determined that this dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur if the dam fails. The estimated damage zone extends approximately 2 miles downstream of the dam. Located within this zone are four dwellings and four barns.

The dam is in the small size classification, since it is greater than 25 feet high but less than 40 feet high, and the maximum storage capacity is greater than 50 acre-ft but less than 1,000 acre-ft.

~~Our~~ inspection and evaluation indicates that the combined spillways do not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The combined spillways will pass 14 percent of the Probable Maximum Flood without overtopping. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The guidelines require that a dam of small size with a high downstream hazard potential pass 50 to 100 percent of the PMF. Considering the low height of dam (33 feet) and the small storage capacity (103 acre-ft), fifty percent of the PMF has been determined to be the appropriate spillway design flood. The 100-year flood (1 percent probability flood) will not overtop the dam. The 1 percent probability flood is one that has a 1 percent chance of being exceeded in any given year.

The embankment was in fair condition. Deficiencies visually observed by the inspection team were: (1) brush and briar growth on upstream and downstream face of embankment; (2) no wave protection for upstream face; (3) fairly large slough on downstream face near midheight of dam; (4) significant erosion at both downstream embankment and abutment contacts; (5) spillway pipe outlet has eroded toe of embankment; and (6) downstream channel lined with trees and brush.

Another deficiency was the lack of seepage and stability analysis records.

It is recommended that the owners take the necessary action without undue delay to correct the deficiencies reported herein. A detailed discussion of these deficiencies is included in the following report.

Steven L. Brady, P.E.
Anderson Engineering, Inc

Gene Wertepny, P.E.
Hanson Engineers, Inc.

Dave Daniels, P.E.
Hanson Engineers, Inc.

Tom Beckley, P.E.
Anderson Engineering, Inc.

AERIAL VIEW OF LAKE AND DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

MACH LAKE DAM
MISSOURI INVENTORY NO. 30133

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APPENDICES

SECTION 1 PROJECT INFORMATION

1.1 GENERAL:

A. Authority:

The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection be made of Mach Lake Dam in Perry County, Missouri.

B. Purpose of Inspection:

The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and a visual inspection in order to determine if the dam poses hazards to human life or property.

C. Evaluation Criteria:

Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, "Recommended Guidelines for Safety Inspection of Dam,, Appendix D." These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT

A. Description of Dam and Appurtenances:

Mach Lake Dam is an earth fill structure approximately 38 feet high and 300 feet long at the crest. The appurtenant work consists of a 14 inch diameter principal spillway steel pipe, a 2 inch cast iron drawdown pipe, and two 18 inch diameter emergency spillway asbestos cement pipes.

Sheet 3 of Appendix A shows a plan, profile, and typical section of the embankments.

B. Location:

The dam is located in the Western part of Perry County, Missouri on a tributary of Hollow Goose Creek. The dam and lake are within the Perryville West, Missouri 7.5 minute quadrangle sheet (Section 17, T35N, R11E, latatude 37° 44.3'; longitude 89° 57.5'). Sheet 2 of Appendix A shows the general vicinity.

C. Size Classification:

With an embankment height of 33 ft and a maximum storage capacity of approximately 103 acre-ft, the dam is in the small size category.

D. Hazard Classification:

The St. Louis District, Corps of Engineers has determined that this dam is in the high hazard potential classification. The estimated damage zone extends approximately 2 miles downstream of the dam. Located within this zone are four dwellings and four barns. The affected features located within the damage zone were field verified by the inspection team.

E. Ownership:

The dam is owned by Mr. Joe Mach, Sr.
The owner's address is #5 Denning Lane, St. Louis, MO 53031

F. Purpose of Dam:

The dam was constructed primarily for erosion control.

G. Design and Construction History:

The dam was constructed in 1972 by Richardet Construction Company of Perryville, Missouri. The Soil Conservation Department provided a design, however it was not followed. All of the construction history as stated below was obtained from Mr. Clarence L. Zahner, 431 North Pine, Perryville, Missouri, who owned the property when the dam was constructed.

Mr. Zahner stated that a core trench approximately 10 feet wide was cut down to bedrock and filled with compacted clay.

The material for the embankment came from the upper end of the lake area and from a road cut near the dam. Mr. Zahner said that select material was used in the core of the embankment. Compaction of the embankment was accomplished by rubber tired scrappers. Two anti-seep collars were installed on the 14 inch diameter principal spillway pipe. The collars were 4 ft by 4 ft and constructed of steel.

No unusual conditions were encountered during construction of the dam. Mr. Zahner and Mr. Mach said there had been no modifications to the dam. However, the dam was not built in accordance with the SCS design. The Perryville, Missouri Office of the SCS said the records were not kept on this dam because the plans were not used by the owner. Therefore, no design plans are available.

Some seepage problems were observed immediately after the lake was constructed. A geologist from the Missouri Geological Survey inspected the dam on April 6, 1973. The report concluded that the seepage was not serious and also noted that the downstream embankment appeared to be oversteep. A slide was noted above the downstream toe.

H. Normal Operating Procedures:

All flows will be passed by the uncontrolled principal spillway pipe and the two emergency spillway pipes. According to the owner, the dam has not been overtopped.

1.3 PERTINENT DATA:

Pertinent data about the dam, appurtenant works, and reservoir are presented in the following paragraphs. Sheet 3 of Appendix A presents a plan, profile, and typical section of the embankment.

A. Drainage Area:

The drainage area for this dam, as obtained from the U.S.G.S. quad sheet is approximately 100 acres.

B. Discharge at Dam Site:

(1) All discharge at the dam site is through uncontrolled spillways.

(2) Estimated Total Spillway Capacity at Maximum Pool (Top of Dam El. 520.6): 24 cfs

(3) Estimated Capacity of Principal Spillway: 11 cfs

(4) Estimated Capacity of Emergency Spillway: 13 cfs.

(5) Estimated Experience Maximum Flood at Dam Site: Unknown

(6) Diversion Tunnel Low Pool Outlet at Pool Elevation: Not Applicable

(7) Diversion Tunnel Outlet at Pool Elevation: Not Applicable

(8) Gated Spillway Capacity at Pool Elevation: Not Applicable

(9) Gated Spillway Capacity at Maximum Pool Elevation: Not Applicable

C. Elevations:

All elevations are consistent with an assumed mean sea level elevation of 519.9 for the top of the 14 inch inlet pipe of the principal spillway (estimated from quadrangle map).

(1) Top of Dam: 520.6 ft., MSL

(2) Principal Spillway Crest: 516.7 ft., MSL

(3) Emergency Spillway Crest: 518.8 ft., MSL

(4) Principal Spillway Pipe Invert at Outlet: 493.0 ft., MSL

(5) Streambed at Centerline of Dam: 487.5 ft., MSL

(6) Pool on Date of Inspection: 509.8 ft., MSL

(7) Apparent High Water Mark: 6 Inches Over Top of Principal Spillway Pipe (According To Mr. Zahner).

(8) Maximum Tailwater: Not Applicable

(9) Upstream Portal Invert Diversion Tunnel: Not Applicable

(10) Downstream Portal Invert Diversion Tunnel: Not Applicable

D. Reservoir Lengths:

(1) At Top of Dam: 1420 ft.

(2) At Emergency Spillway Crest: 1300 ft.

(3) At Principal Spillway Crest: 1150 ft.

E. Storage Capacities:

(1) At Top of Dam: 103 Acre-ft.

(2) At Emergency Spillway Crest: 87 Acre-ft.

(3) At Principal Spillway Crest: 73 Acre-ft.

F. Reservoir Surface Areas:

(1) At Top of Dam: 9.5 Acres

(2) At Emergency Spillway Crest: 8.5 Acres

(3) At Principal Spillway Crest: 5.0 Acres

G. Dam:

(1) Type: Rolled Earth

(2) Length at Crest: 300 ft.

(3) Height: 33 ft.

(4) Top Width: 13 ft.

(5) Side Slopes: Upstream 2.8 H on 1V;
Downstream varies from 2.0 H on 1V to 2.3 H on 1V

(6) Zoning: Apparently homogeneous

(7) Impervious Core: Selected clay soil.

(8) Cutoff: Key Trench to bedrock

(9) Grout Curtain: None

H. Diversion and Regulating Tunnel:

(1) Type: Not Applicable

(2) Length: Not Applicable

(3) Closure: Not Applicable

(4) Access: Not Applicable

(5) Regulating Facilities: Not Applicable

I Spillway:

1.1 Principal Spillway:

(1) Location: Station 2+07

(2) Type: 14 Inch Diameter Steel Pipe

(3) Upstream Channel: Not Applicable

(4) Downstream Channel: Well defined earth channel, brush and tree lined, moderate slopes.

1.2 Emergency Spillway:

(1) Location: North Abutment

(2) Type: Two 16 Inch Diameter Asbestos Cement Pipes

(3) Upstream Channel: Grass Lined Earth Cut Channel

(4) Downstream Channel: No Definable Channel, Area Grass and Tree Lined.

J. Regulating Outlets:

There is a 2 inch drawdown pipe located with the principal spillway pipe. The pipe is controlled by a valve on the upstream side and the pipe apparently discharges into the principal spillway pipe (see Photo No. 15).

SECTION 2 ENGINEERING DATA

2.1 DESIGN

There were no design calculations or engineering drawings prepared for the dam as constructed. No documentation of construction inspection records were available. There are no documented maintenance data.

A. Surveys:

No pre-construction or post-construction survey data were available.

Sheet 3 of Appendix A presents a plan, profile and cross section of the dam from survey data obtained during the site inspection. The top of the 14 inch inlet pipe of the principal spillway was used as our site datum. The mean sea level elevation of 519.0 for our site datum was estimated from the Perryville West, Missouri 7.5 minute quadrangle sheet.

B. Geology and Subsurface Materials:

The site is located along the Eastern edge of the Ozarks geologic region of Missouri. The Ozarks are characterized topographically by hills, plateaus, and deep valleys. The most common bedrock types are dolomite, sandstone, and chert. The "Geologic Map of Missouri" indicates that the bedrock in the site area consists of the Jefferson City, Cotter, Powell, and Smithville formations. The Missouri Geological Survey Office indicates that the bedrock at the site is probably of the Jefferson City formation. The Jefferson City formation consists of light brown to brown, medium to finely crystalline dolomite and argillaceous dolomite.

The "Geologic Map of Missouri" indicates several normal faults located north and west of the site. The site is located in seismic zone 2 (moderate damage zone) but is close to the boundary of zone 3 (major damage zone, see Sheet 4 of Appendix B).

The soils are of the Union-Fullerton-McGirk Soil Association and have developed from thin loess deposited over weathered material from cherty dolomite (see Leossial Thickness Map, sheet 2 of Appendix B). Auger probes in the embankment indicate the soils to be brown, rocky, clayey silts (ML-CL).

C. Foundation and Embankment Design:

No foundation and embankment design information was available. Seepage and stability analyses apparently were not performed as required in the Corps of Engineers guidelines. The previous owner indicated that a core trench of 10 feet width and unknown depth, was excavated to bedrock. All embankment fill material was obtained from the lake bed area and a road cut.

D. Hydrology and Hydraulics:

No hydrologic and hydraulic design computations are available for this dam. Based on field measurements of spillway dimensions and embankment elevations and the watershed area, lake area and storage data from U.S.G.S. quadrangle sheets, hydrologic analyses using U.S. Army Corps of Engineers guidelines were performed and appear in Appendix C.

E. Structure:

There are no structures associated with this dam.

2.2 CONSTRUCTION

No construction inspection data are available.

2.3 OPERATION

Normal flows would be passed by the 14 inch steel pipe principal spillway and by the two 16 inch asbestos cement pipe emergency spillway.

2.4 EVALUATION

A. Availability:

No engineering data, seepage or stability analyses, or construction test data were available.

B. Adequacy:

The engineering data available were inadequate to make a detailed assessment of the design, construction, and operation of this structure. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record

C. Validity:

To our knowledge, no valid engineering data on the design or construction of the embankment are available.

SECTION 3 VISUAL INSPECTION

3.1 FINDINGS

A. General:

The field inspection was made on January 29, 1981. The inspection team consisted of personnel from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The team members were:

Steven L. Brady - Anderson Engineering, Inc (Civil Engineer)
Tom R. Beckley - Anderson Engineering, Inc. (Civil Engineer)
Gene Wertepny - Hanson Engineers, Inc. (Hydraulic Engineer)
Dave Daniels - Hanson Engineers, Inc (Geotechnical Engineer)

Photographs of the dam, appurtenant structures, reservoir, and downstream features are presented in Appendix D.

B. Dam:

The embankment appears to be in fair condition with grass cover noted on the upstream and downstream slopes of the embankment. The 13 foot wide crest of the embankment was graveled and a road extended across the crest. The embankment was constructed fairly straight and the vertical alignment was fairly level.

The slopes of the embankment were relatively constant. The upstream slope was 2.8 H on 1V and the downstream slope varied from 2.0 H on 1V to 2.3 H on 1V. No surface cracking of the embankment was noted. Considerable erosion was noted at both downstream embankment abutment contacts. The left junction erosion gully was approximately 3 feet deep and 3 feet wide.

A large inactive slough was noted on the downstream face of the embankment. The slough was at station 1 + 50 and at about the mid-height of the dam. The slough was approximately 25 feet across and a large mound of soil was at the base of the slough. The slough appears to be a slope failure and may be the slide referred to in the Geologist's report of April 6, 1973 (see sheet 4 of Appendix B).

The slopes of the embankment were briar and brush covered. Several large (12 to 15 inches diameter) tree stumps were noted on the upstream face. No erosion on the slopes or animal burrows were observed. No riprap was noted along the upstream slope.

No water except for a small puddle of water in the downstream channel near the toe, was noted that would indicate any seepage.

The principal spillway outlet discharges on the downstream face. A plunge pool has eroded into the embankment as shown in Photo No. 16.

Shallow auger probes of the embankment indicated the embankment soil to consist of a brown, rocky clayey silt (Unified Soil Classification System of ML-CL).

No instrumentation (monuments, piezometers, etc.) were observed.

C. Appurtenant Structures:

C.1 Principal Spillway:

The principal spillway consisted of a 14 inch diameter steel pipe with a 14 inch diameter steel pipe trash shield (see Photo No. 13). The inlet was clear. The outlet was clear and a plunge pool had formed in the lower part of the embankment. A 2 inch steel drawdown pipe and valve are located at the inlet and discharges into the principal spillway pipe. Mr. Zahner said the maximum water level in the lake had been 6 inches over the principal spillway.

C.2 Emergency Spillway:

The emergency spillway consists of two 16 inch asbestos cement pipes located at the north abutment. The emergency spillway discharge channel is not definable and is tree and grass lined.

D. Reservoir:

The watershed is primarily wooded with moderate to steep slopes. No significant erosion or sloughing was noted. No significant siltation was noted and it is not considered to be a problem.

E. Downstream Channel:

The downstream channel is brush and tree lined with a well defined channel. The side slopes are moderate to steep.

3.2 EVALUATION

The embankment is in fair structural condition. Brush and briar growth on the dam constitute a potential hazard and encourage animal burrowing. Lack of wave protection could result in increased erosion to the front face of the embankment. The large slough on the downstream face, erosion at the contacts, and erosion of the principal spillway discharge could worsen and seriously affect the structural stability of the dam.

SECTION 4 OPERATIONAL PROCEDURES

4.1 PROCEDURES

We are not aware of any operational procedures. The pool is normally controlled by rainfall, runoff, evaporation, and the capacity of the uncontrolled spillways.

4.2 MAINTENANCE OF DAM:

No scheduled maintenance of the dam is known to be provided.

4.3 MAINTENANCE OF OPERATING FACILITIES

There are no operating facilities.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

The inspection team is unaware of any existing warning system for this dam.

4.5 EVALUATION

The briar and brush growth on the dam, the slough area, the lack of riprap, and the eroded areas are deficiencies which could become serious if not corrected. A program of regular maintenance of the dam should be established.

SECTION 5 HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

A. Design Data:

No hydrologic and hydraulic design data for this dam were available.

B. Experience Data:

No recorded rainfall, runoff, discharge, or reservoir stage data were available for this lake and watershed. The previous owner of the dam indicated that the highest water level occurred when the water level was 6 inches above the principal spillway.

C. Visual Observations:

The principal spillway pipe appears in good condition. The discharge has eroded a plunge pool into the embankment. Approaches to both spillways are clear. Emergency spillway discharges appear to be away from the toe of the embankment, although there is no definable channel. The downstream channel is densely overgrown with trees and brush.

D. Overtopping Potential:

The hydraulic and hydrologic analyses (using the U.S. Army Corps of Engineers guidelines and the HEC-1 computer program) were based on: (1) a field survey of spillway dimensions and embankment elevation, and (2) an estimate of the reservoir storage and the pool and drainage areas from the Perryville West, Missouri, 7.5 minute U.S.G.S. quad sheet.

Based on the hydrologic and hydraulic analyses presented in Appendix C, the combined spillways will pass 14 percent of the Probable Maximum Flood. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The recommended guidelines from the Department of the Army, Office of the Chief of Engineers, require that this structure (small size with high downstream hazard potential) pass 50 percent to 100 percent of the PMF, without overtopping. Considering the small storage capacity and low height of the dam, 50 percent of the PMF has been determined to be the appropriate spillway design flood. The spillways will pass the 1 percent probability flood without overtopping the dam.

Application of the probable maximum precipitation (PMP), minus losses, resulted in a flood hydrograph peak inflow of 2,250 cfs. For 50 percent of the PMP, the peak inflow was 1,120 cfs.

The routing of the PMF through the spillways and dam indicates that the dam will be overtopped by 2.2 feet at elevation 522.8. The duration of the overtopping will be 12.4 hours, and the maximum outflow will be 1,980 cfs. The maximum discharge capacity of the spillways is 24 cfs. The routing of 50 percent of the PMF indicates that the dam will be overtopped by 1.5 feet at elevation 522.1. The maximum outflow will be 810 cfs, and the duration of overtopping will be 8.9 hours. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

SECTION 6 STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

A. Visual Observations:

Observed features which could adversely affect the structural stability of this dam are discussed in Sections 3.1 B and 3.2.

B. Design and Construction Data

Seepage and stability analyses comparable to the requirements of the guidelines were not available, which constitutes a deficiency which should be rectified.

C. Operating Records:

No operating records have been obtained.

D. Post-Construction Changes:

There have been no modifications to the dam.

E. Seismic Stability:

The structure is located in seismic zone 2. It is recommended that the prescribed seismic loading for this zone be applied in stability analyses performed for this dam.

SECTION 7 ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

This Phase I inspection and evaluation should not be considered as being comprehensive since the scope of work contracted for is far less detailed than would be required for an in-depth evaluation of dams. Latent deficiencies, which might be detected by a totally comprehensive investigation, could exist.

A. Safety:

The embankment is generally in fair condition. Several items were noted during the visual inspection which should be investigated further, corrected, or controlled. These items are: (1) brush and briar growth on upstream and downstream face of embankment; (2) no wave protection for upstream face; (3) fairly large slough on downstream face near midheight of dam; (4) significant erosion at both downstream embankment and abutment contacts; (5) spillway pipe outlet has eroded toe of embankment; and (6) downstream channel lined with trees and brush.

Another deficiency was the lack of seepage and stability analyses records.

The dam will be overtopped by flows in excess of 14 percent of the Probable Maximum Flood. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

B. Adequacy of Information:

The conclusions in this report were based on review of the information listed in Section 2.1, the performance history as related by others, and visual observation of external conditions. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

C. Urgency:

The remedial measures recommended in paragraph 7.2 should be accomplished without undue delay. If the deficiencies listed in paragraph 7.1.A are not corrected, and if good maintenance is not provided, the embankment condition will continue to deteriorate and possibly could become serious in the future. The items recommended in paragraph 7.2.A should be pursued promptly.

D. Necessity for Additional Inspection:

Based on the results of the Phase I inspection, no Phase II inspection is recommended.

E. Seismic Stability

The structure is located in seismic zone 2. It is recommended that the prescribed seismic loading for this zone be applied in any stability analyses performed for this dam.

7.2 REMEDIAL MEASURES

The following remedial measures and maintenance procedures are recommended. All remedial measures should be performed under the guidance of a professional engineer experienced in the design and construction of dams.

A. Alternatives:

(1) Spillway size and/or height of dam should be increased to pass 50 percent of the PMF. In either case, the spillway should be protected to prevent erosion.

B. O and M Procedures:

(1) Seepage and stability analyses comparable to the requirements of the recommended guidelines should be performed by an engineer experienced in the construction of dams.

(2) The slough area at midheight on the downstream face should be [illegible].

(3) The briar and brush growth should be cut periodically.

(4) Wave protection should be provided for the upstream face [illegible].

(5) The plunge pool and around end of principal spillway [illegible] riprapped.

(6) Eroded areas at the dam-abutment contacts should be repaired and maintained.

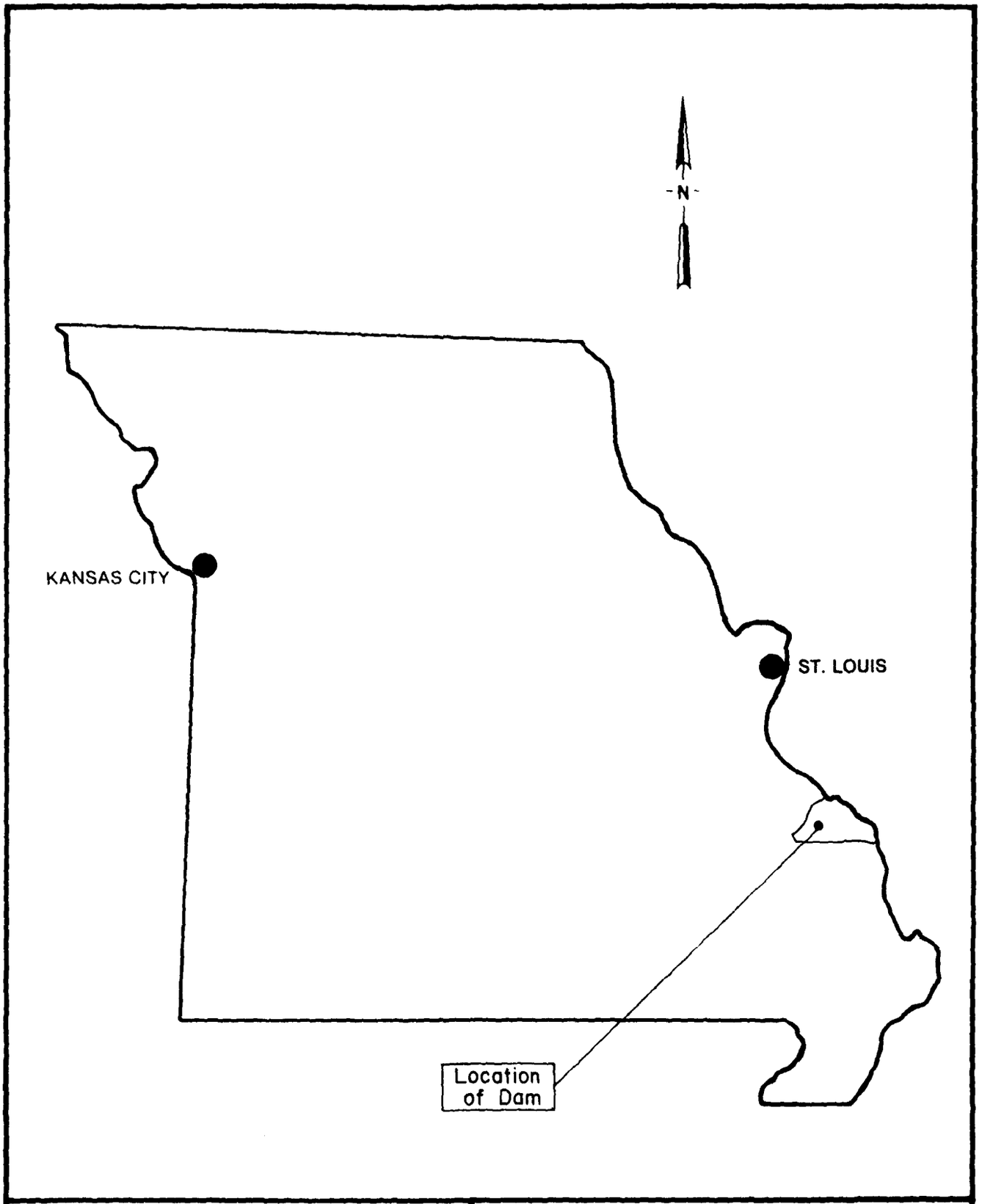
(7) The small water area in the downstream channel should be [illegible] to be sure this is not seepage under the dam.

(8) Brush and tree growth should be removed from the spillway [illegible].

(9) A detailed inspection of the dam should be made periodically by an engineer experienced in the design and construction of dams.

APPENDIX A

Dam Location and Plans



LOCATION MAP

HANSON ENGINEERS

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Mach Lake Dam
Perry County, Missouri
Mo. I.D. No. 30133

SHEET 1, APPENDIX A

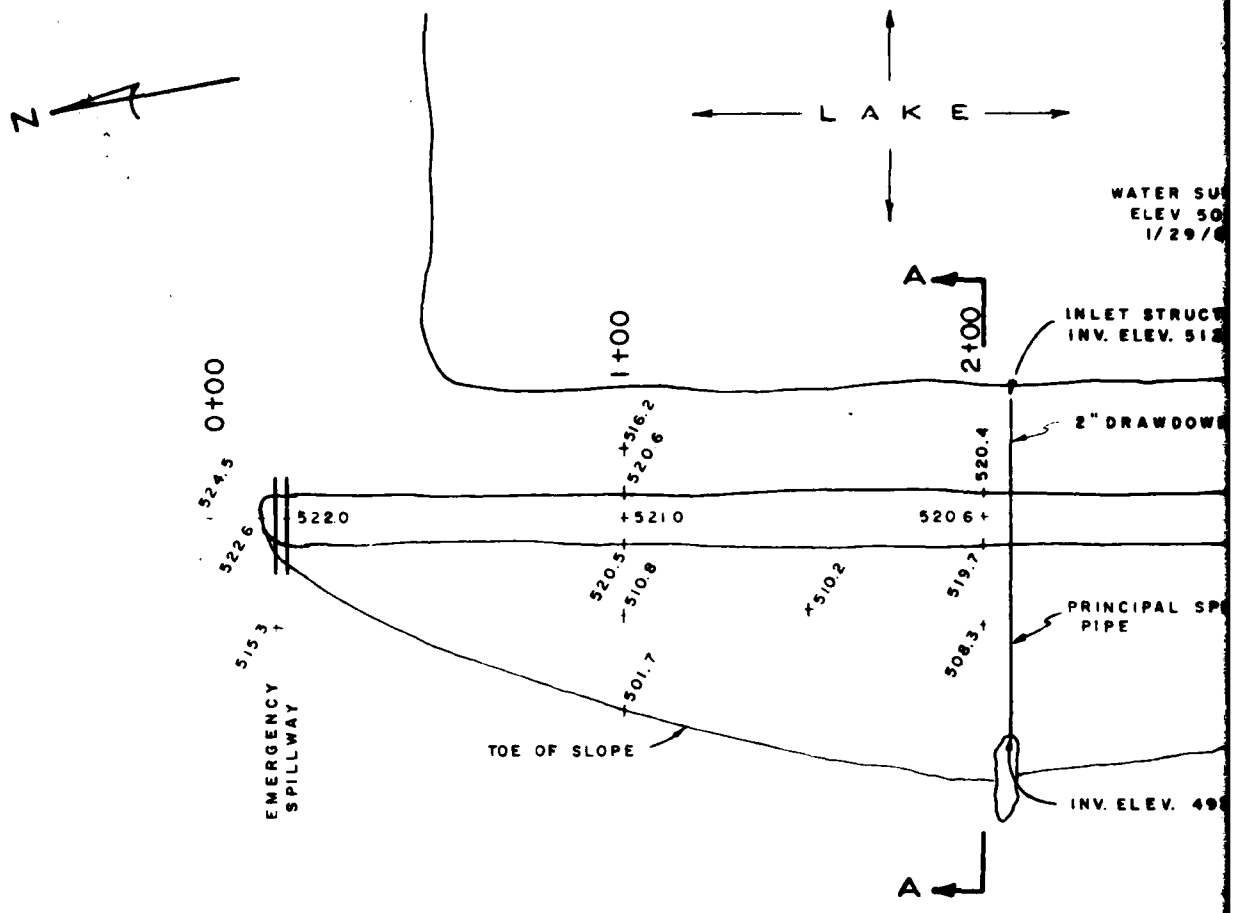
VICINITY MAP

HANSON ENGINEERS INCORPORATED

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

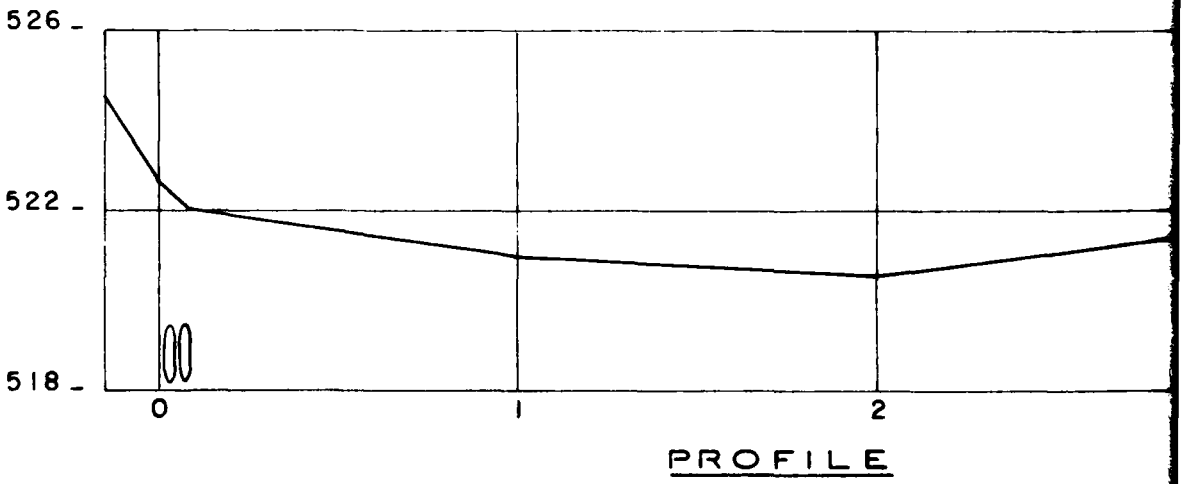
Mach Lake Dam
Perry County, Missouri
Mo. I.D. No. 30133

Sheet 2, Appendix A



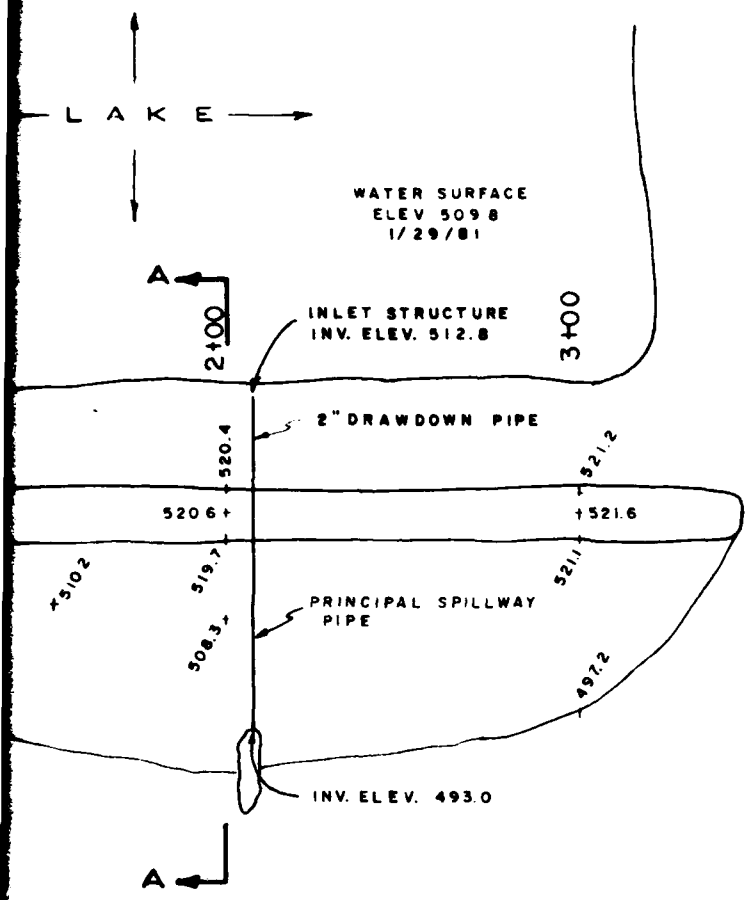
BENCHMARK:
TOP OF 14 in INLET PIPE
STA 2+07, 29ft. RIGHT.
ELEV. 519.0 M.S.L.

PLAN VIEW
SCALE: 1" = 50'

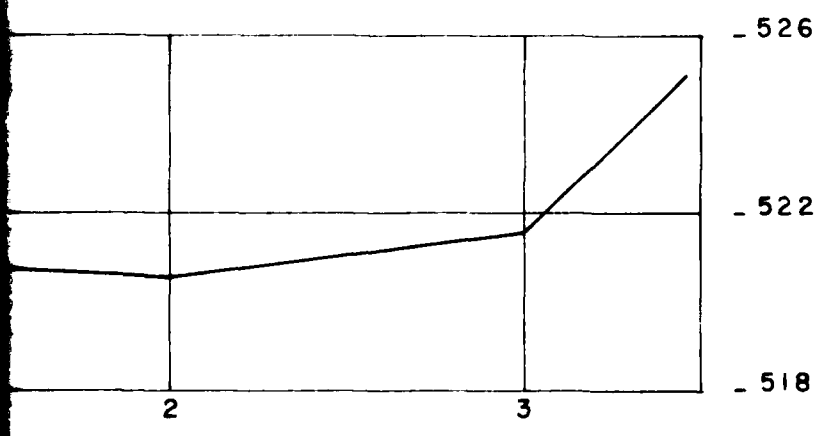


PROFILE

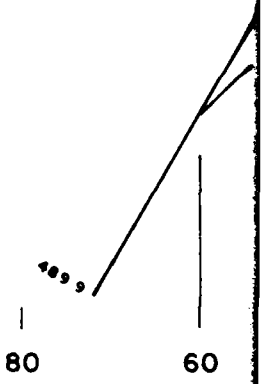
2

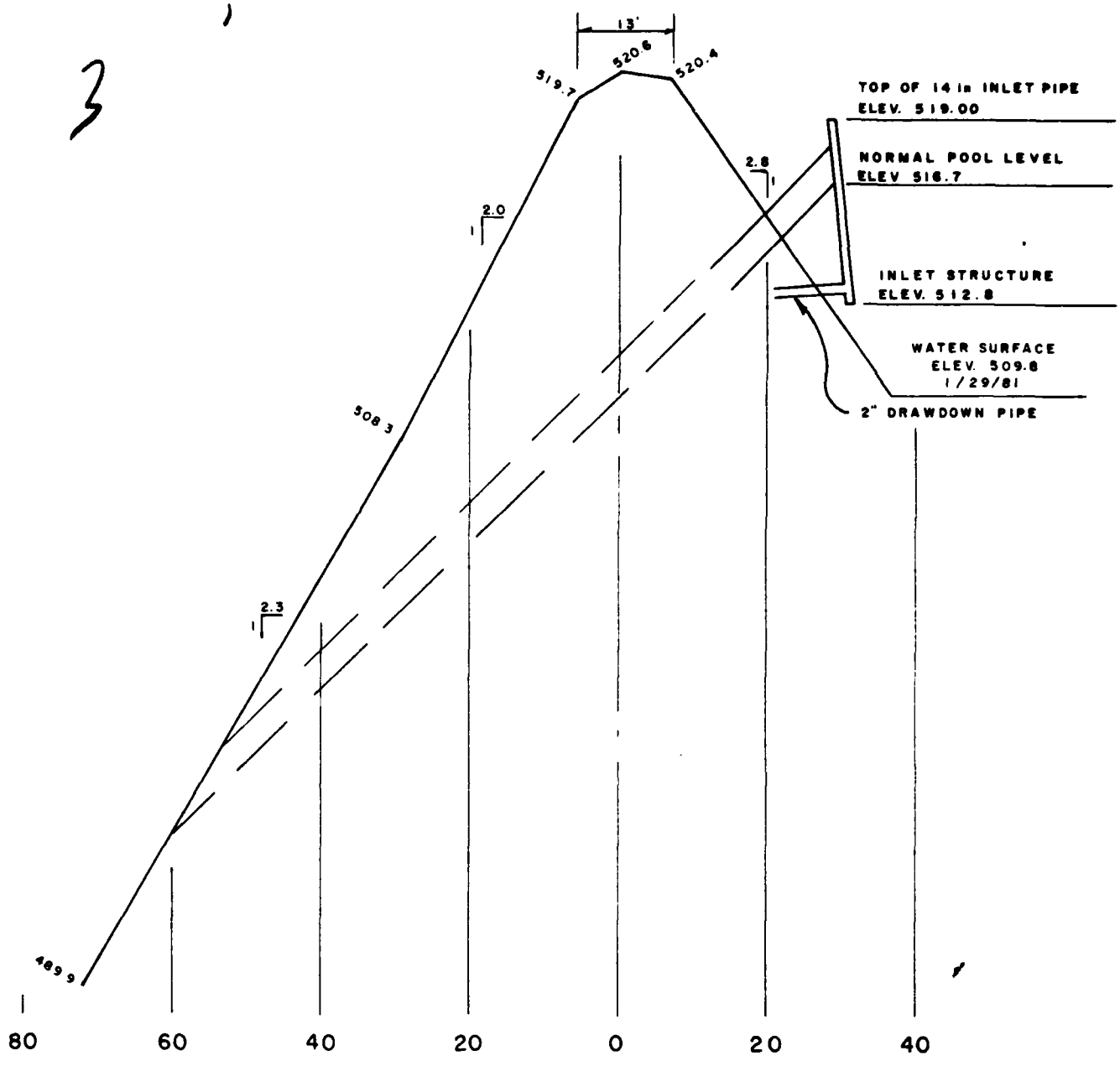


PLAN VIEW
SCALE 1" = 50'



OFILE

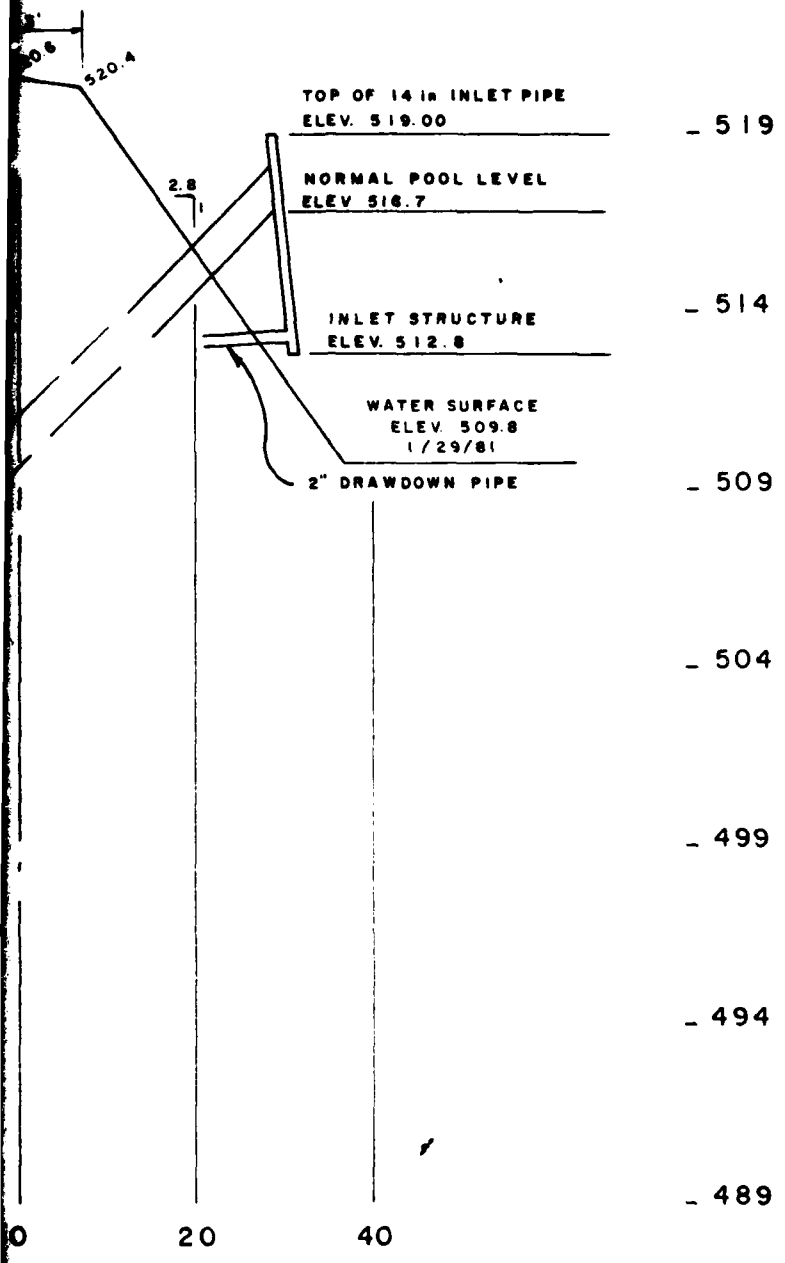




SECTION A-A STA 2+00

A/

730 N.



STA 2+00

A/E ANDERSON ENGINEERING, INC.
730 N. BENTON AVE. • SPRINGFIELD, MO. 65802

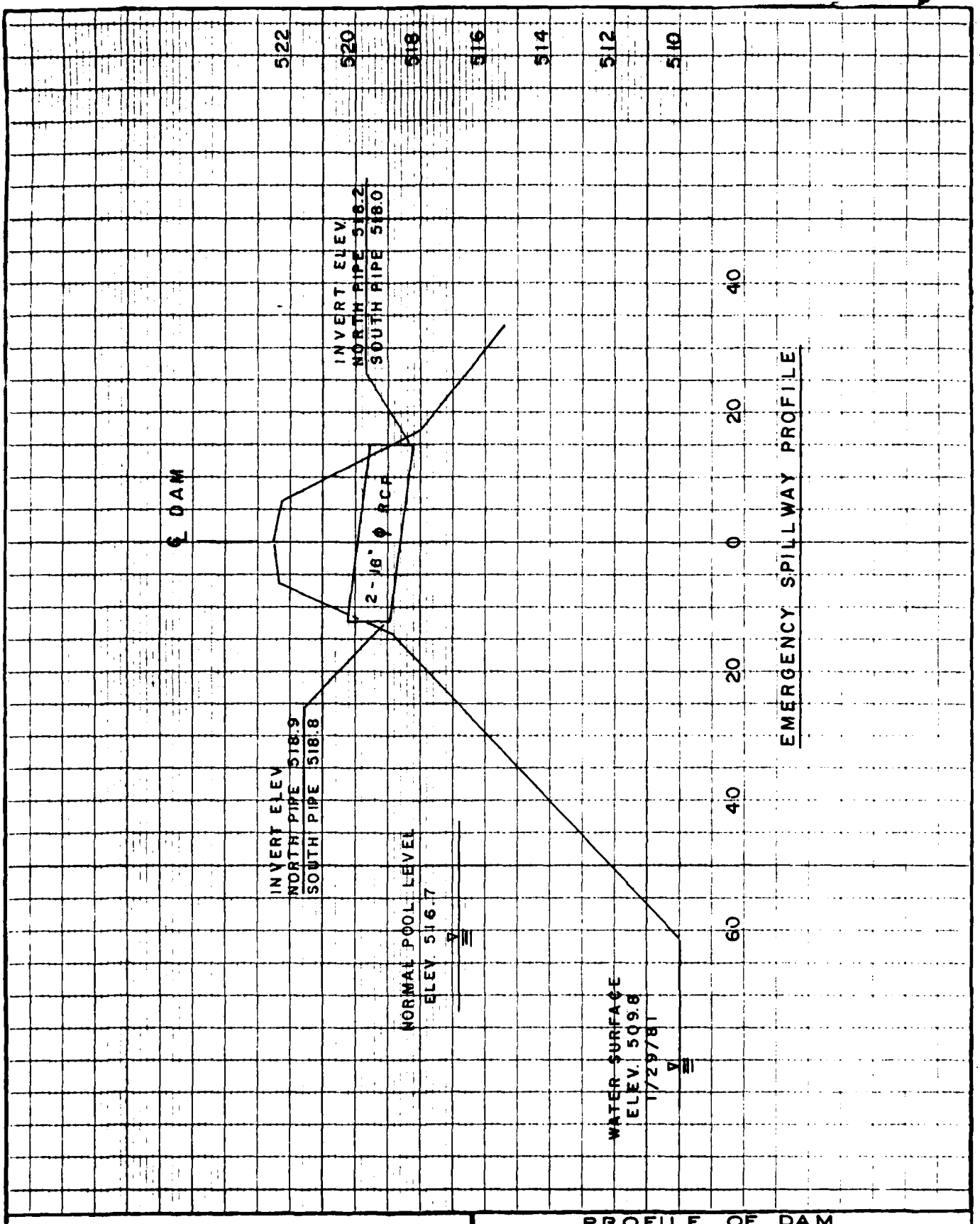
MACH LAKE DAM

MO. No. 30133

PLAN & PROFILE

PERRY COUNTY, MISSOURI

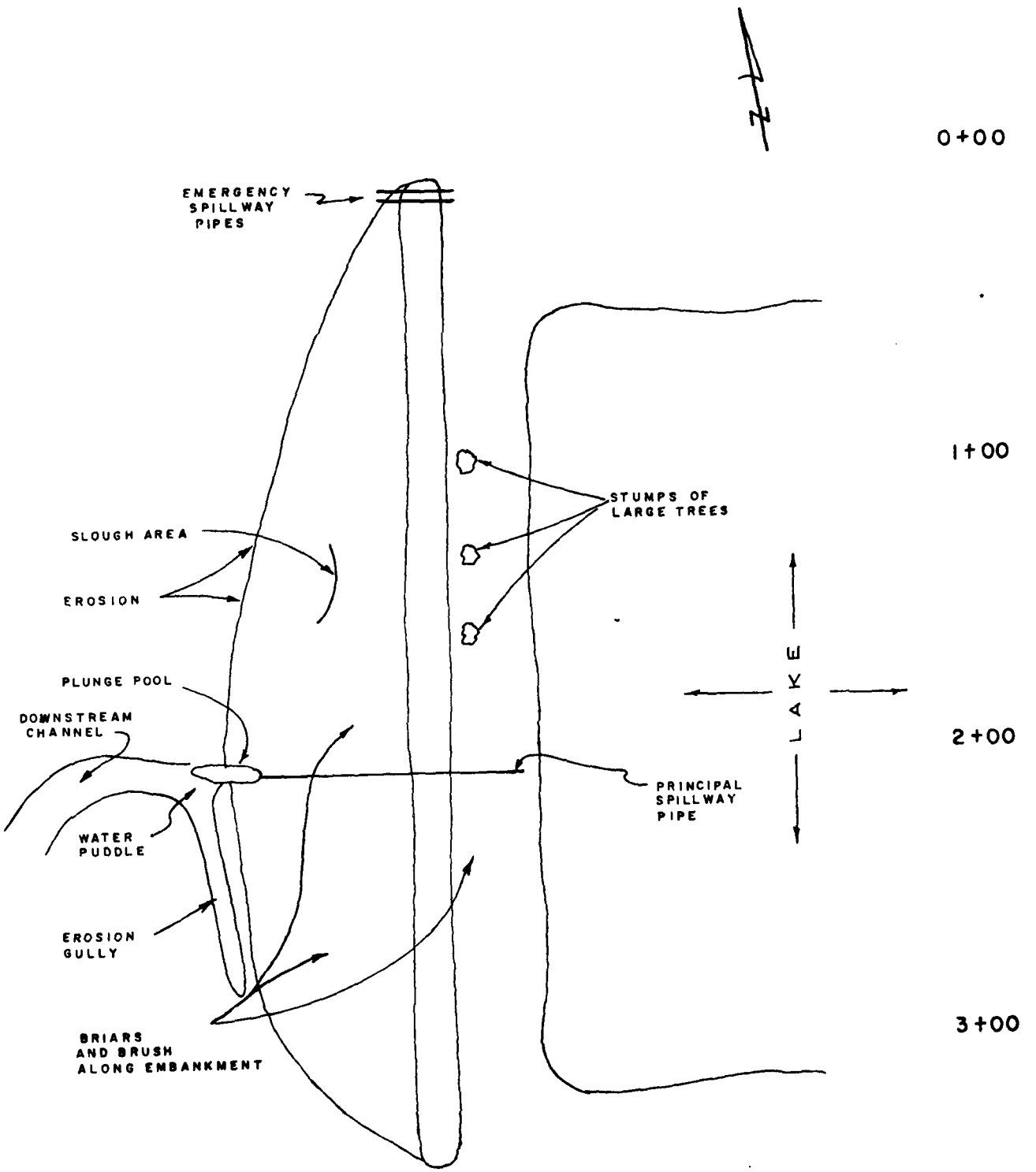
SHEET 3, APPENDIX A



A/E ANDERSON ENGINEERING, INC.
720 N. BENTON AVE. • SPRINGFIELD, MO. 65802

PROFILE OF DAM
MACH LAKE DAM
PERRY COUNTY, MISSOURI
MO. I. D. No. 30133

SHEET 4, APPENDIX A



PLAN SKETCH OF DAM

A/E ANDERSON ENGINEERING, INC.
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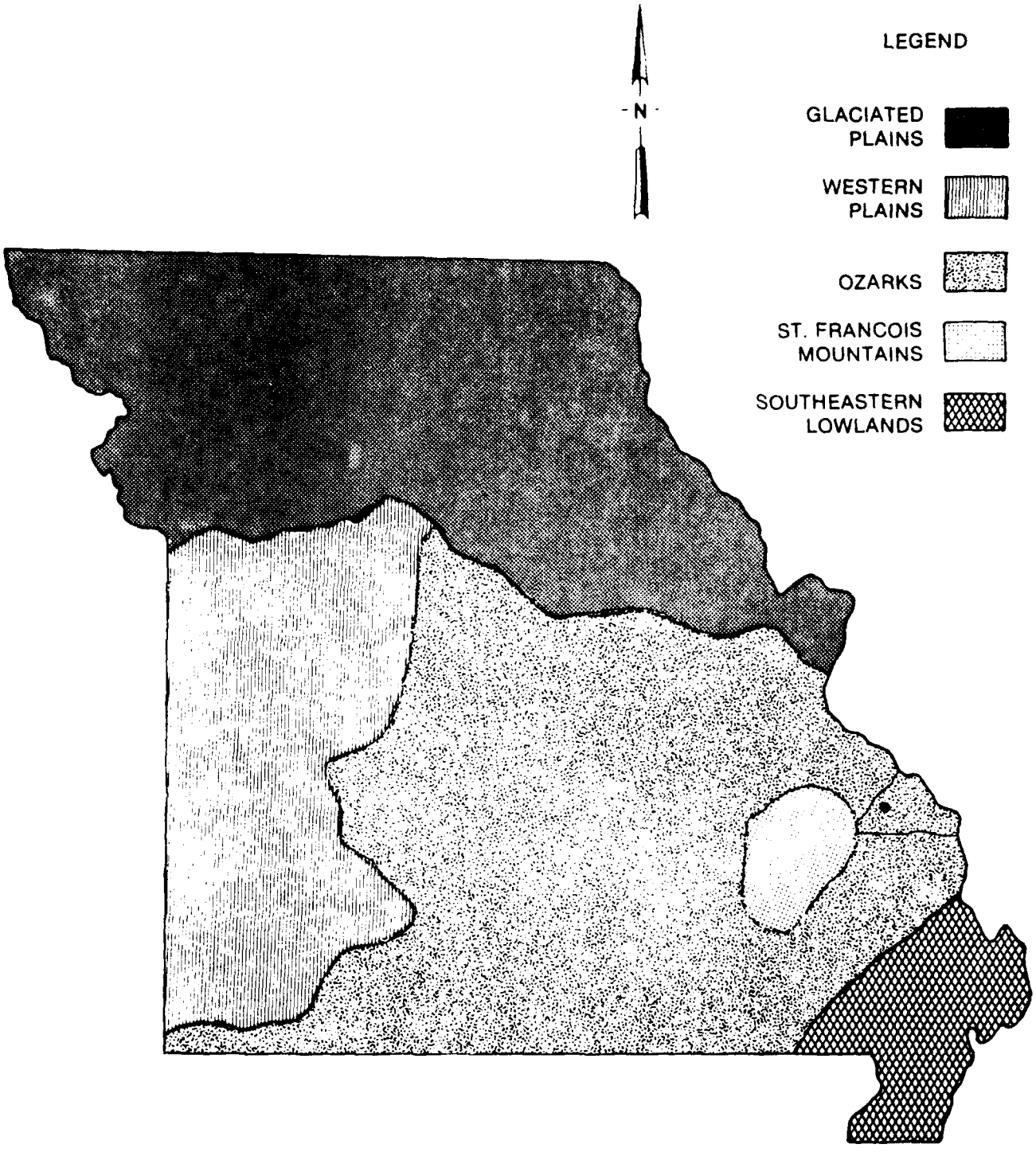
MACH LAKE DAM
PERRY COUNTY, MISSOURI
MO. I. D. No. 30133

SHEET 5 , APPENDIX A

APPENDIX B

Geology and Soils



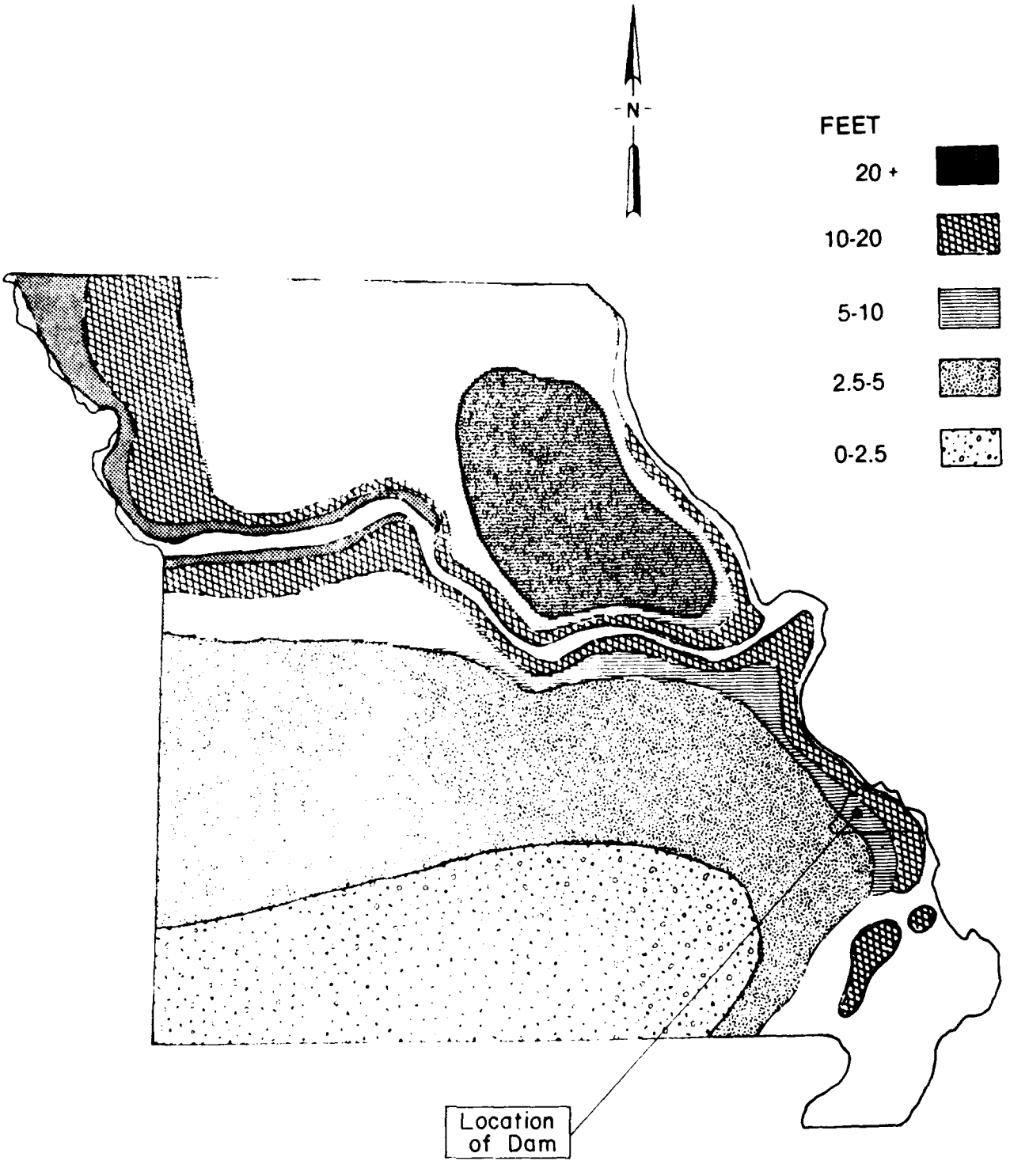
MAJOR GEOLOGIC REGIONS OF MISSOURI

HANSON ENGINEERS

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Mach Lake Dam
Perry County, Missouri
Mo. I.D. No. 30133

SHEET 1, APPENDIX B

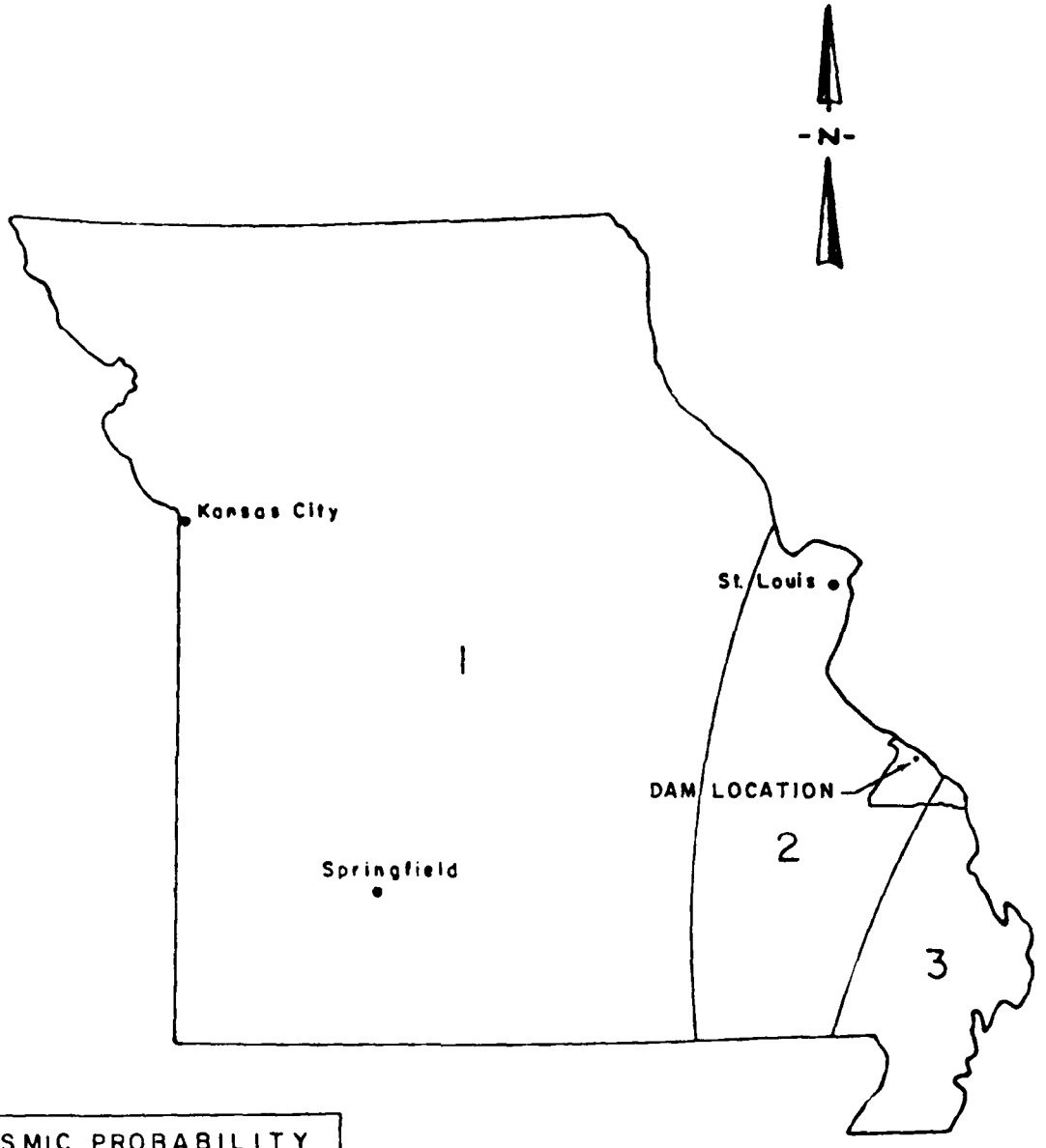


HANSON ENGINEERS

SPRINGFIELD IL • PEORIA IL • ROCKFORD IL

Mach Lake Dam
Perry County, Missouri
Mo. I.D. No. 30133

SHEET 2, APPENDIX B



SEISMIC PROBABILITY	
ZONE	DAMAGE
1	MINOR
2	MODERATE
3	MAJOR

A/E ANDERSON ENGINEERING, INC.
730 N. BENTON AVE. • SPRINGFIELD, MO. 65802

SEISMIC ZONE MAP

MACH LAKE DAM
PERRY COUNTY, MISSOURI
MO. I.D. No. 30133

136

BB

ENGINEERING GEOLOGIC REPORT OF THE JACK ZAHNER LAKE

Perry County, Missouri

LOCATION: Dam site in the SW¼, SE¼, NW¼, sec. 17, T. 35 N., R. 10 E., Perryville 15' Quadrangle.

The small 7-8 acre lake was constructed approximately 1½ years ago and has recently filled due to heavy rainfall in the area. The lake was reported to have dropped approximately 48 inches during the time it was filling. Some of this water loss could be attributed to normal soaking of the lake basin and partially because of high evaporation experienced during the dry summer months.

Water was flowing out the spillway on the date of this investigation with small amounts of seepage evident on the downstream toe of the dam. No large volume water loss was noted within several hundred yards downstream of the dam. The seeps particularly on the lower left abutment appear to be coming through the contact between the natural ground line and the dam, particularly in the vicinity of the old stream bed near the left valley wall. No estimates of the total amount of seepage was made, but it is anticipated that the quantities are small enough to have only a minor affect on the water line during dry months, unless conditions worsen. A slump in the crest of the dam near the left abutment probably is helping to seal off leakage conditions which may have been greater in the past, as some of the older seeps were not flowing on this date.

There is a slide developing above the downstream toe that should be corrected as soon as possible. The slide plane is open and the entry of rainwater will probably aggravate the slide condition. It is recommended that a berm be placed on the downstream side of the dam to prevent further sliding. The downstream embankment appears to be oversteep.

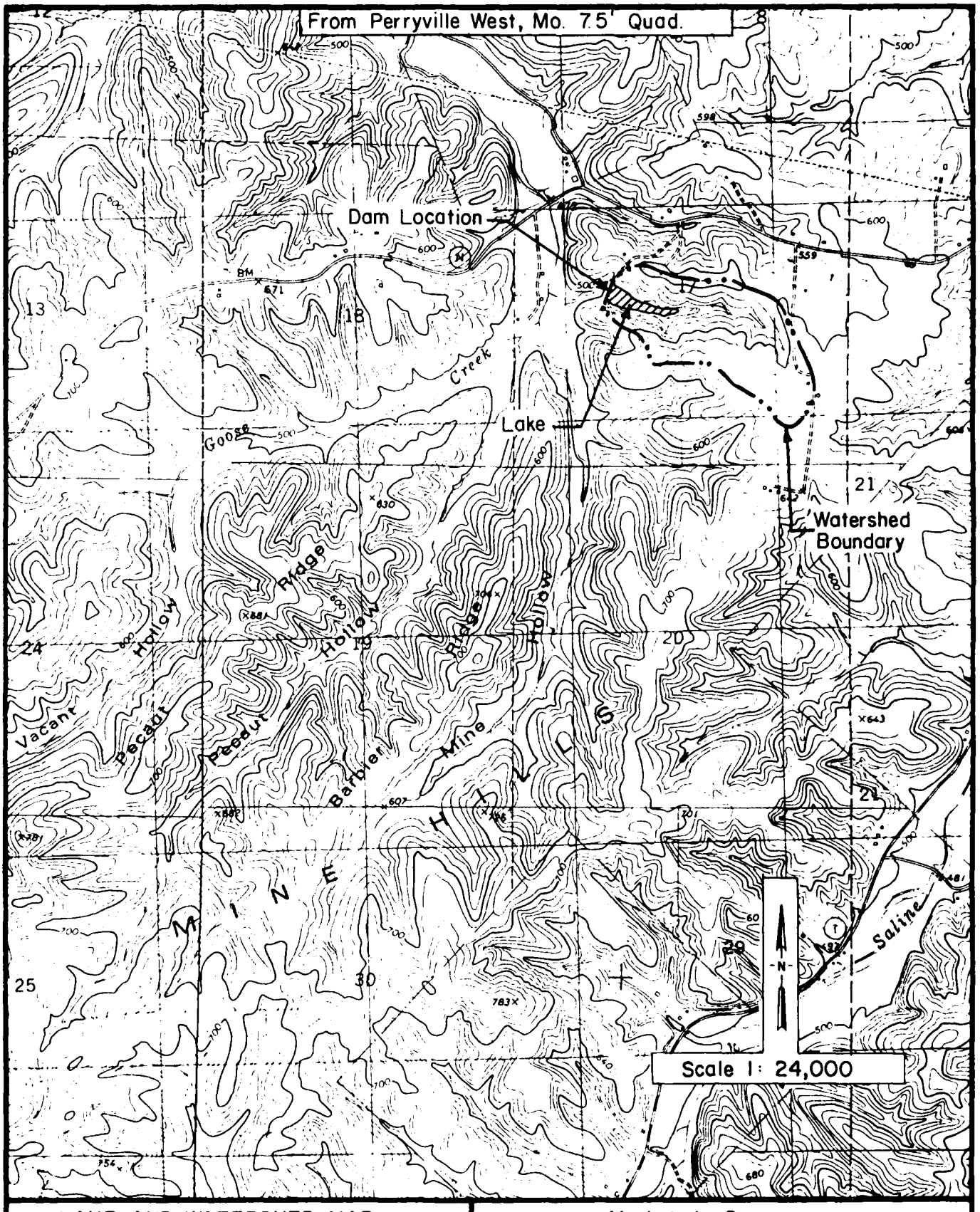
SUMMARY:

No recommendations to correct the present seepage is made. No severe leakage was noted on the date of this investigation. If piping of materials from the dam is observed in the future, recommendations for correction of the problem may be made at that time.

Thomas J. Dean, Geologist
Applied Engineering & Urban Geology Section
Missouri Geological Survey
JUNE 6 1973

APPENDIX C

Overtopping Analysis



LAKE AND WATERSHED MAP

HANSON ENGINEERS INCORPORATED

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Mach Lake Dam
Perry County, Missouri
Mo. I.D. No. 30133

Sheet 1, Appendix C

APPENDIX C

HYDROLOGIC AND HYDRAULIC ANALYSIS

To determine the overtopping potential, flood routings were performed by applying the Probable Maximum Precipitation (PMP) to a synthetic unit hydrograph to develop the inflow hydrograph. The inflow hydrograph was then routed through the reservoir and spillway. The overtopping analysis was accomplished using the systemized computer program HEC-1 (Dam Safety Version), July 1978, prepared by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California.

The PMP was determined from regional charts prepared by the National Weather Service in "Hydrometeorological Report No. 33." Reduction factors were not applied. The rainfall distribution for the 24-hour PMP storm duration was assumed according to the procedures outlined in EM 1110-2-1411 (SPD Determination). Also, the 1 percent chance probability flood was routed through the reservoir and spillway. St. Genevieve, Missouri rainfall distribution (5 min. interval - 24 hours duration), as provided by the St. Louis District, Corps of Engineers, was used in this case.

The synthetic unit hydrograph for the watershed was developed by the computer program using the SCS method. The time of concentration was estimated using the Kirpich formula. This formula and the parameters for the unit hydrograph are shown in Table 1 (Sheet 4, Appendix C). The time of concentration was also verified from velocity estimates for the average slopes of the watershed and the main channel (Design of Small Dams, page 70, 1974 Edition).

The SCS curve number (CN) method was used in computing the infiltration losses for rainfall-runoff relationship. The CN values used for the antecedent moisture conditions (AMC), and the result from the computer output, are shown in Table 2 (Sheet 5, Appendix C).

The reservoir routing was accomplished by using the Modified Puls Method assuming the starting lake elevation at normal pool. No antecedent storm was routed in order to determine the starting elevation. It was assumed that the mean annual high water elevation corresponds with the normal pool elevation. The hydraulic capacity of the spillway was used as an outlet control in the routing. The hydraulic capacity of the spillways and the storage capacity of the reservoir were defined by the elevation-surface area--storage-discharge relationships shown in Table 3 (Sheet 5, Appendix C).

The rating curve for the spillways (see Table 4 Sheet 6, Appendix C) was determined assuming pipes with entrance and outlet control, and using charts from the U. S. Bureau of Public Roads.

The flow over the crest of the dam during overtopping was determined using the non-level dam option ($L and $V cards) of the HEC-1 program. The program assumes critical flow over a broad-crested weir. The lowest elevation of the crest of the dam, obtained from survey measurements, was assumed as top of dam elevation.

A summary of the routing analysis for different ratios of the PMF is shown in Table 5 (Sheet 7, Appendix C). The result of the routings indicates that the spillway will pass the 1 percent probability flood without overtopping the dam.

The computer input data, a summary of the output data, and a plot of the inflow-outflow hydrograph for the PMF are presented on Sheets 8, 9, and 10 of Appendix C.

TABLE 1

SYNTHETIC UNIT HYDROGRAPH

Parameters:

Drainage Area (A)	0.16	sq miles
Length of Watercourse (L)	0.59	miles
Difference in elevation (H)	143	ft
Time of concentration (Tc)	0.21	hrs
Lag Time (Lg)	0.13	hrs
Time to peak (Tp)	0.17	hrs
Peak Discharge (Qp)	455	cfs
Duration (D)	5	min.

Time (Min.)(*)	Discharge (cfs)(*)
0	0
5	202
10	452
15	328
20	140
25	64
30	29
35	13
40	6
45	3
50	1

(*) From the computer output

FORMULA USED:

$$Tc = \left(\frac{11.9\ L^3}{H}\right)^{0.385}$$

Kirpich Formula.
From California Culverts Practice, California Highways and Public Works, September, 1942.

$$Lg = 0.6\ Tc$$

$$Tp = \frac{D}{2} + Lg$$

$$Qp = \frac{484\ A.Q}{Tp}$$

Q = Excess Runoff = 1 inch

TABLE 2

RAINFALL-RUNOFF VALUES

Selected Storm Event	Storm Duration (Hours)	Rainfall (Inches)	Runoff (Inches)	Loss (Inches)
PMP	24	34.3	32.8	1.5
1% Prob. Flood	24	7.1	4.3	2.8

Additional Data:

1) Soil Conservation Service Soil Group C
2) Soil Conservation Service Runoff Curve CN = 88 (AMC III) for the PMF
3) Soil Conservation Service Runoff Curve CN = 74 (AMC II) for the 1 percent probability flood
4) Percentage of Drainage Basin Impervious 5 percent

TABLE 3

ELEVATION, SURFACE AREA, STORAGE AND DISCHARGE RELATIONSHIPS

Elevation (feet-MSL)	Lake Surface Area (acres)	Lake Storage (acre-ft)	Spillway Discharge (cfs)
487.5	0	0	-
*516.7	5.0	73	0
**518.8	8.5	87	7
520.0	9.0	98	18
***520.6	9.5	103	24
525.0	11.0	148	49
540.0	15.0	-	-

*Principal spillway crest elevation
**Emergency spillway crest elevation
***Top of dam elevation

The above relationships were developed using data from the USGS Perryville West, Missouri 7.5 minute quadrangle map with a 20 ft contour interval, and the field measurements.

TABLE 4

SPILLWAYS RATING CURVE

Reservoir Elevation (MSL)	Principal Spillway (cfs)	Emergency Spillway (cfs)	Total Discharge (cfs)
*516.7	0	-	0
518.0	4	-	4
**518.8	7	0	7
520.0	10	8	18
***520.6	11	13	24
521.0	12	16	28
522.0	13	20	33
523.0	14	25	39
524.0	15	28	43
525.0	17	32	49

*Principal spillway crest elevation
**Emergency spillway crest elevation
***Top of dam elevation

Method Used: Assuming pipes with entrance and outlet control, and using charts from the U.S. Bureau of Public Roads.

TABLE 5

RESULTS OF FLOOD ROUTINGS

Ratio of PMF	Peak Inflow (cfs)	Peak Lake Elevation (ft, MSL)	Total Storage (acre-ft)	Peak Outflow (cfs)	Depth (ft) Over Top of Dam
-	0	*516.7	73	0	-
0.10	224	519.7	95	15	-
0.14	315	**520.6	103	24	0
0.15	337	520.8	105	34	0.2
0.20	449	521.1	108	104	0.5
0.25	561	521.5	112	285	0.9
0.30	673	521.7	114	468	1.1
0.40	897	521.9	116	700	1.3
0.50	1,120	522.1	118	910	1.5
0.75	1,683	522.4	122	1,446	1.8
1.00	2,250	522.8	125	1,980	2.2

*Principal spillway crest elevation
**Top of dam elevation

The percentage of the PMF that will reach the top of the dam is 14 percent.

```
A        OVERTOPPING ANALYSIS FOR MACK LAKE DAM ( # 6 )
A        STATE ID NO. 30133  COUNTY NAME : PERRY
A        HANSON ENGINEERS INC. DAM SAFETY INSPECTION JOB # 81S3001
B    288                 5
B1     5
J      1        9       1
J1   .10      .15     .20     .25     .30     .40     .50     .75     1.0
K      0        1                                3       1
K1       INFLOW HYDROGRAPH COMPUTATION **
M      1        2    0.16            0.16       1                       1
P      0     26.4     102     120     130
T                                                       -1     -88             0.05
W2  0.21     0.13
X      0     -.1       2
K      1        2                       0       4       1
K1       RESERVOIR ROUTING BY MODIFIED PULS AT DAM SITE **
Y                                       1       1
Y1     1                                                73      -1
Y4 516.7   518.0   518.8   520.0   520.6   521.0   522.0   523.0   524.0   525.0
Y5     0       4       7      18      24      28      33      39      43      49
$S     0      73      87      98     103     148
$E 487.5   516.7   518.8   520.0   520.6   525.0
$$ 516.7
$D 520.6
$L     0     140     255     300     315     325     335     345
$V 520.6   521.0   521.6   522.0   522.6   523.0   523.5   524.0
K     99
```

PMF RATIOS
INPUT DATA

********** ********** ********** ********** **********

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

				RATIOS APPLIED TO FLOWS								
OPERATION	STATION	AREA	PLAN	RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5	RATIO 6	RATIO 7	RATIO 8	RATIO 9
				0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.75	1.00
HYDROGRAPH AT	1	0.16	1	224.	337.	449.	561.	673.	897.	1122.	1683.	2244.
	(	0.41)	(	6.35)(	9.53)(	12.71)(	15.88)(	19.06)(	25.41)(	31.76)(	47.65)(	63.53)
ROUTED TO	2	0.16	1	15.	34.	104.	285.	468.	700.	914.	1446.	1976.
	(	0.41)	(	0.43)(	0.96)(	2.95)(	8.08)(	13.25)(	19.82)(	25.87)(	40.93)(	55.95)

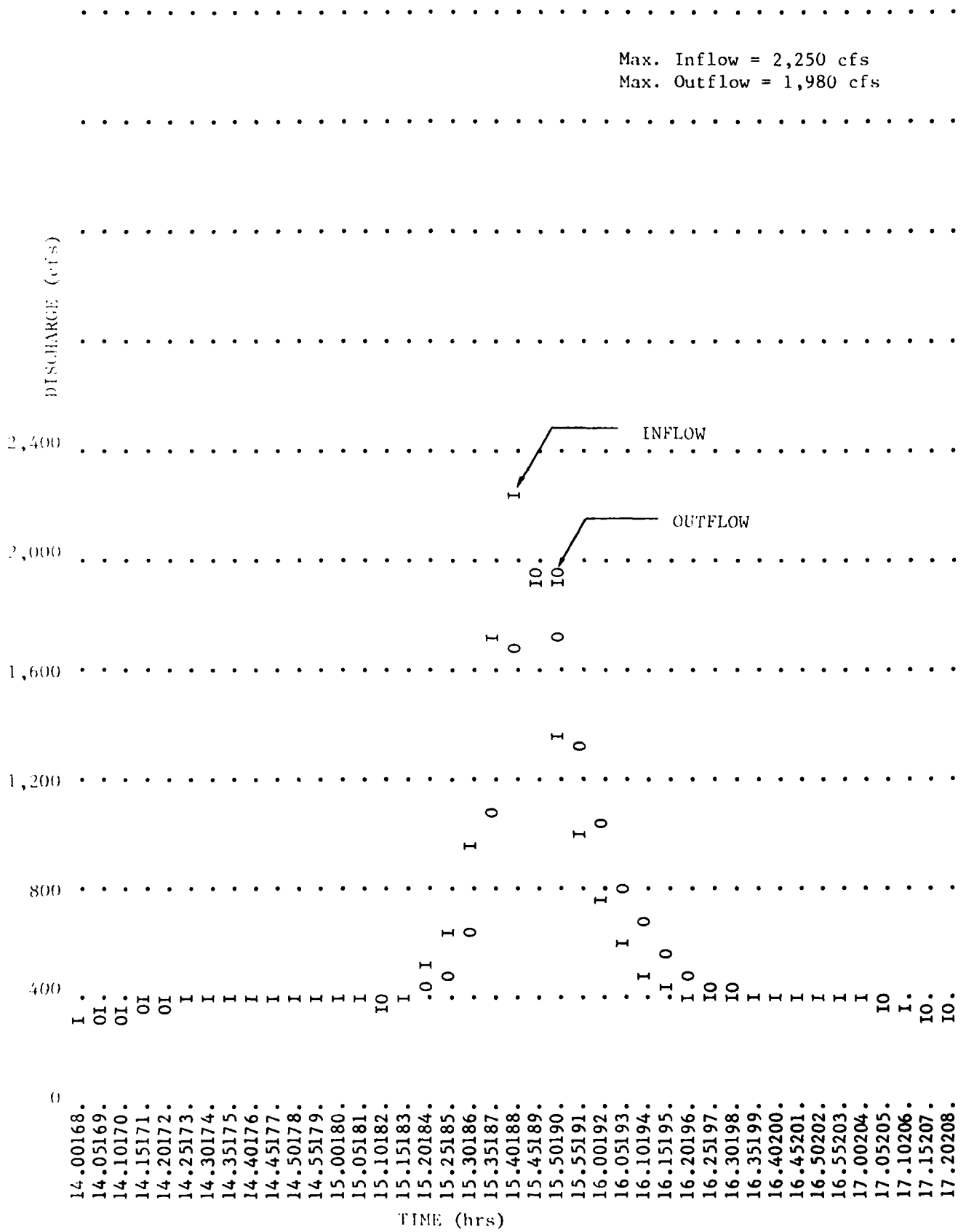
SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	516.70	516.70	520.60
STORAGE	73.	73.	103.
OUTFLOW	0.	0.	24.

PMF RATIOS
OUTPUT DATA

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.10	519.71	0.00	95.	15.	0.00	18.58	0.00
0.15	520.81	0.21	105.	34.	3.42	18.17	0.00
0.20	521.11	0.51	108.	104.	5.08	16.17	0.00
0.25	521.45	0.85	112.	285.	5.50	15.92	0.00
0.30	521.67	1.07	114.	468.	6.33	15.83	0.00
0.40	521.90	1.30	116.	700.	7.75	15.75	0.00
0.50	522.07	1.47	118.	914.	8.92	15.75	0.00
0.75	522.44	1.84	122.	1446.	11.50	15.75	0.00
1.00	522.75	2.15	125.	1976.	12.42	15.75	0.00



INFLOW-OUTFLOW HYDROGRAPH
FOR THE PMF

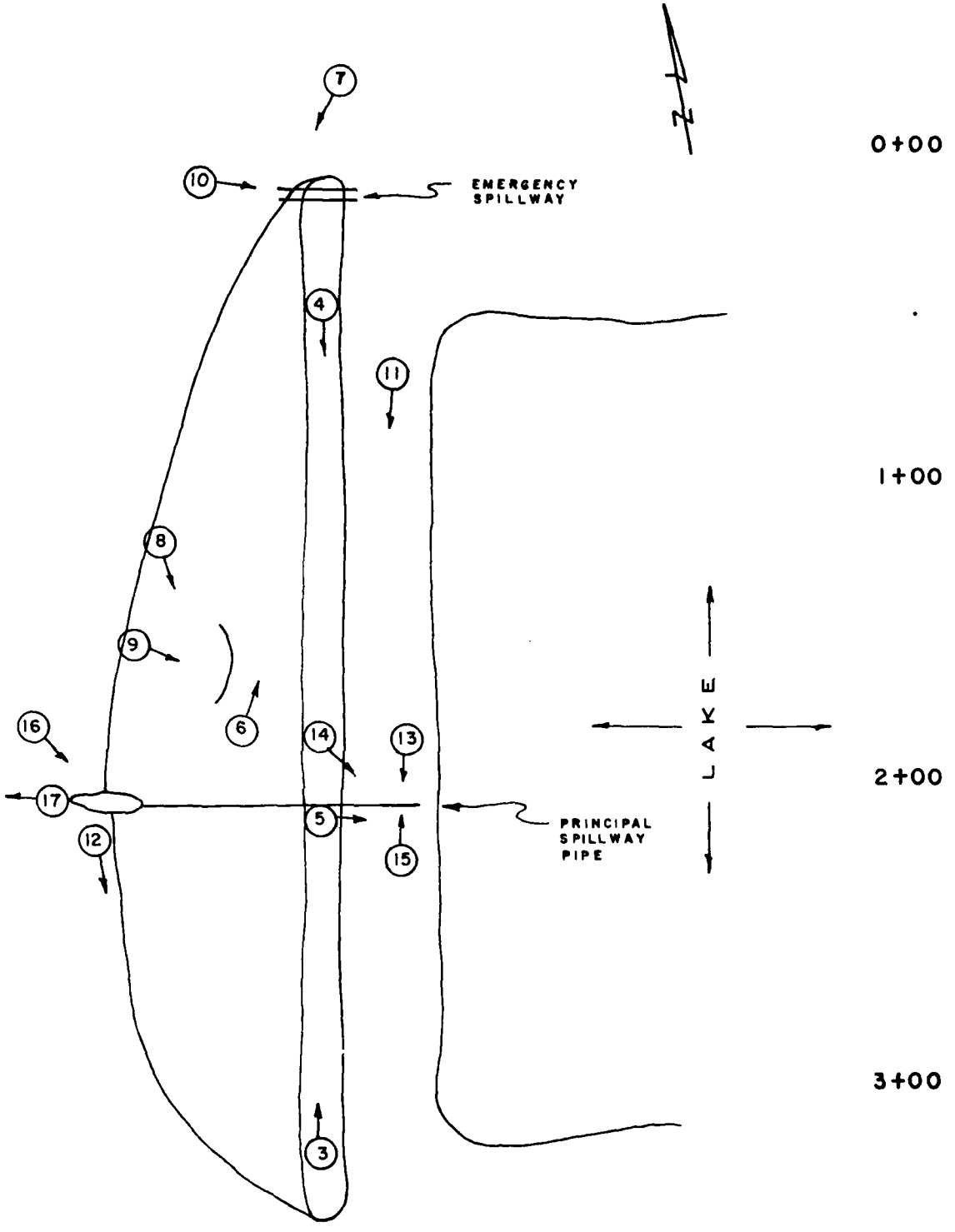
Sheet 10, Appendix C

APPENDIX D

Photographs

LIST OF PHOTOGRAPHS

Photo No.	Description
1	Aerial View (Looking South)
2	Aerial View (Looking Northeast)
3	Crest of Dam (Looking North)
4	Crest of Dam (Looking South)
5	Reservoir and Watershed (Looking East)
6	Downstream Face of Dam (Looking North)
7	Dowstream Face of Dam (Looking South)
8	Downstream Face of Dam Showing Slough Area (Looking South)
9	Slough Area
10	Discharge of Emergency Spillway (Looking East)
11	Upstream Face of Dam (Looking Southwest)
12	Left, Downstream Contact Erosion
13	Principal Spillway Pipe
14	Principal Spillway Pipe
15	Drawdown Pipe
16	Principal Spillway Outlet and Plunge Pool
17	Principal Spillway Downstream Channel
18	Downstream Hazard Feature
19	Downstream Hazard Feature
20	Downstream Hazard Feature



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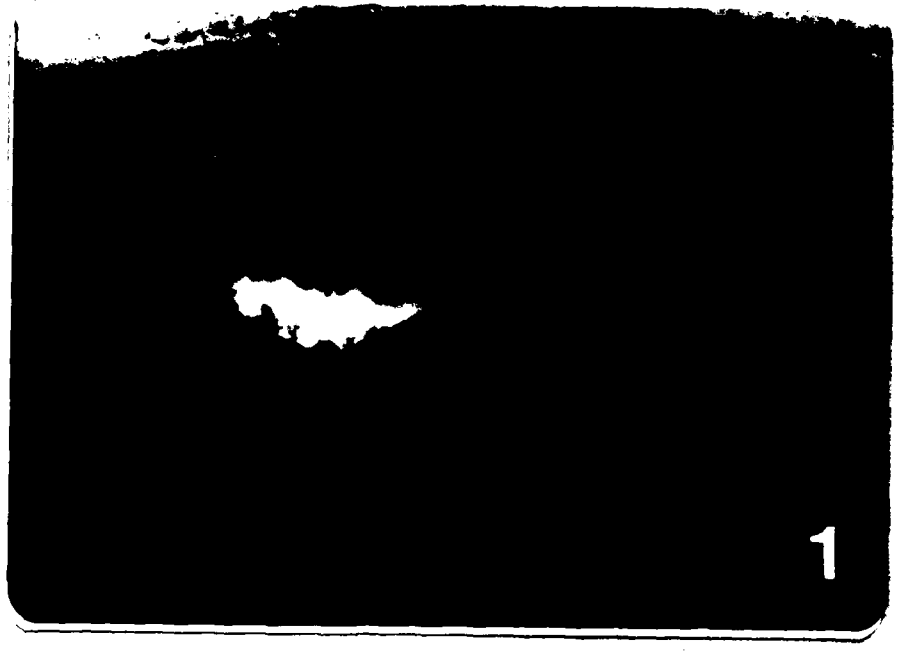
PHOTOGRAPHIC INDEX

MACH LAKE DAM
PERRY COUNTY, MISSOURI
MO. I. D. No. 30133

SHEET 2 , APPENDIX D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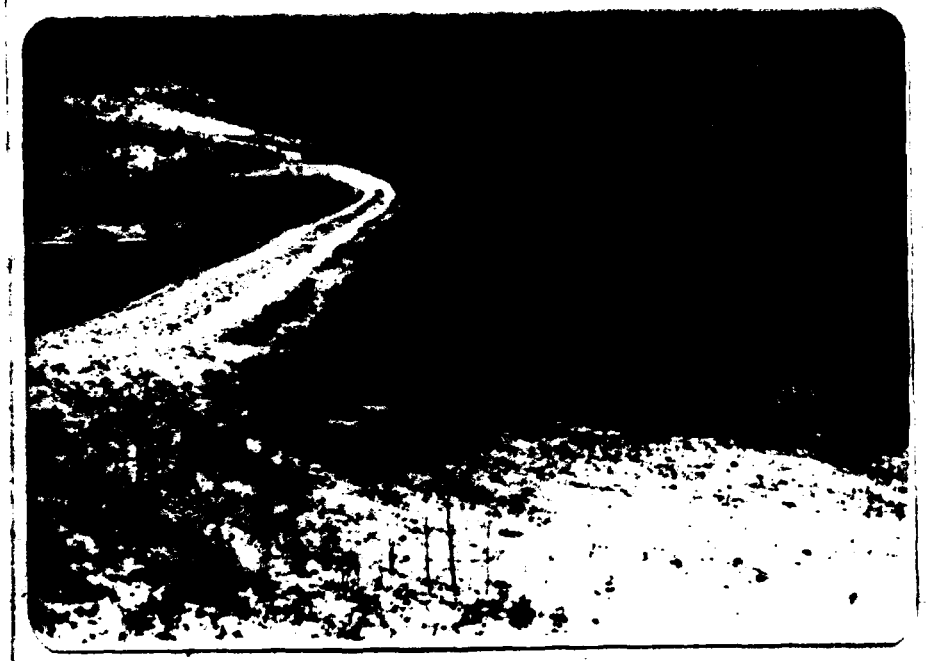


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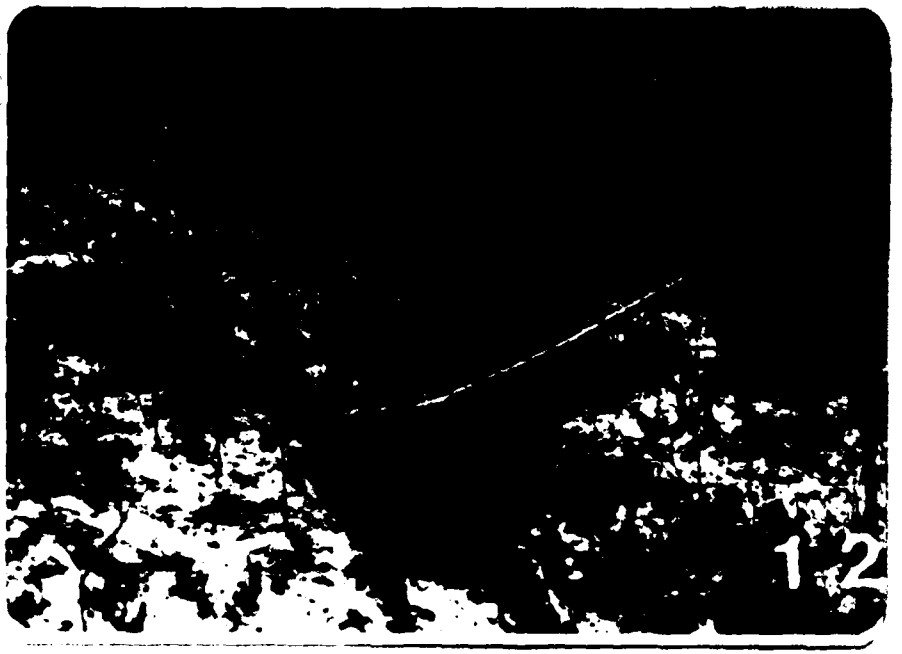
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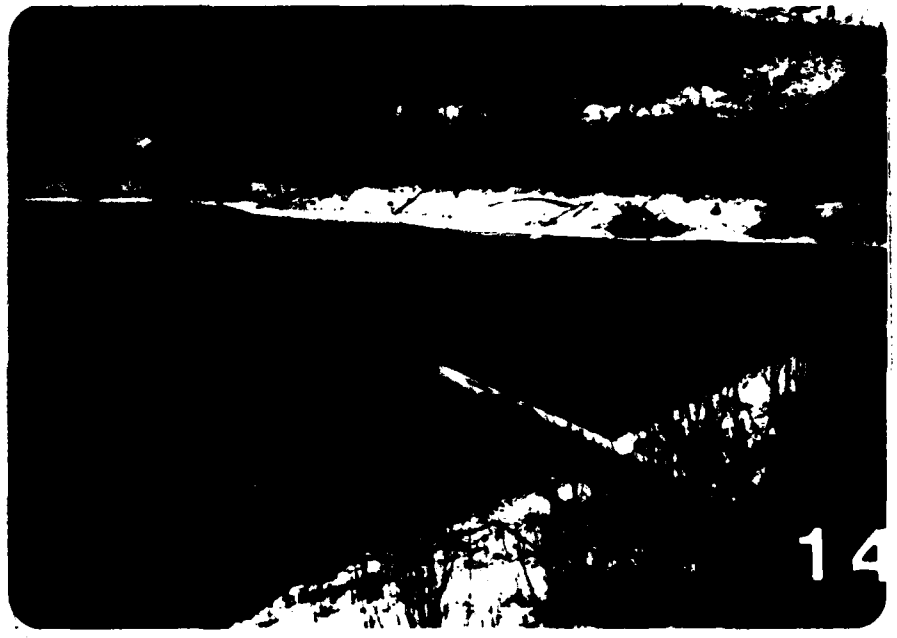
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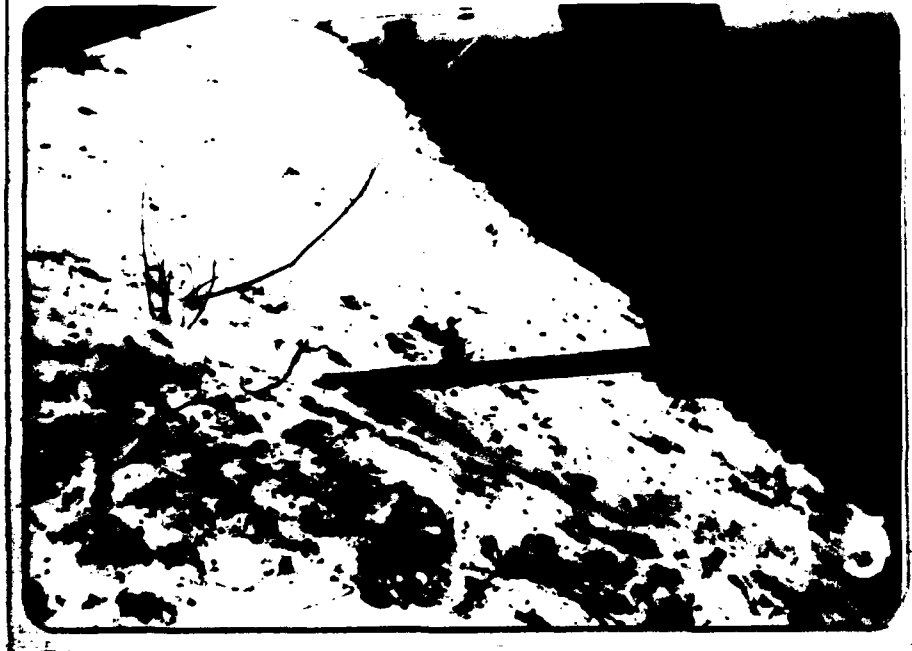


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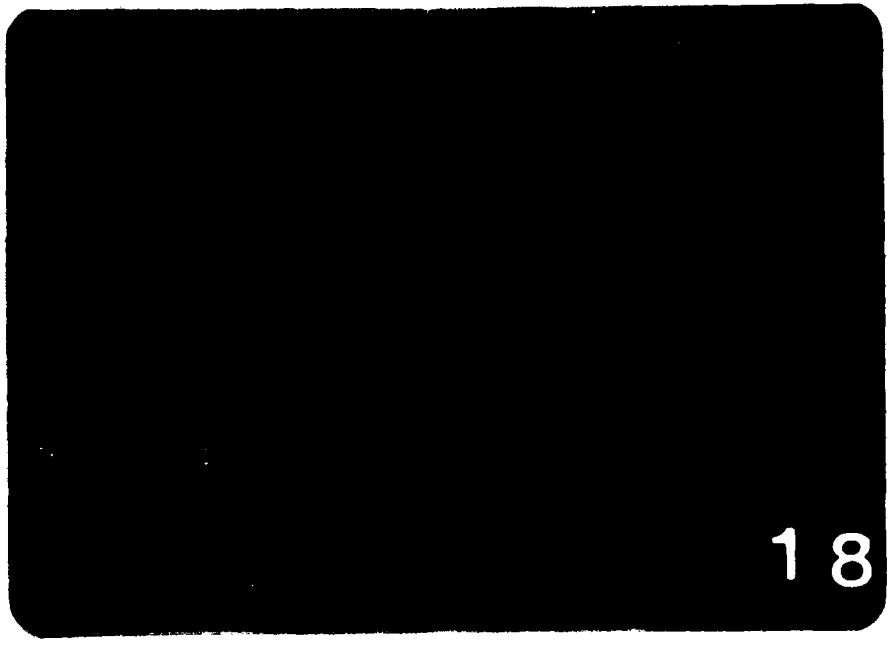
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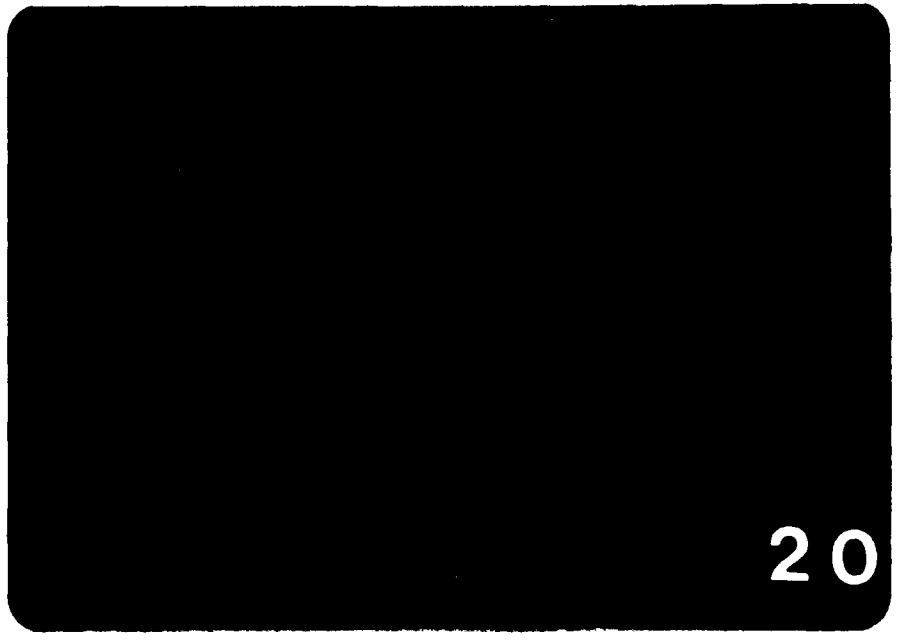
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